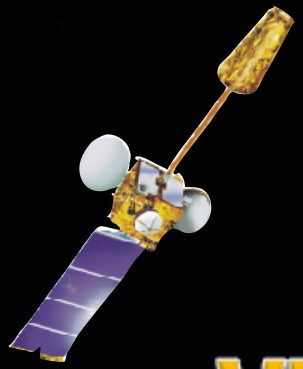
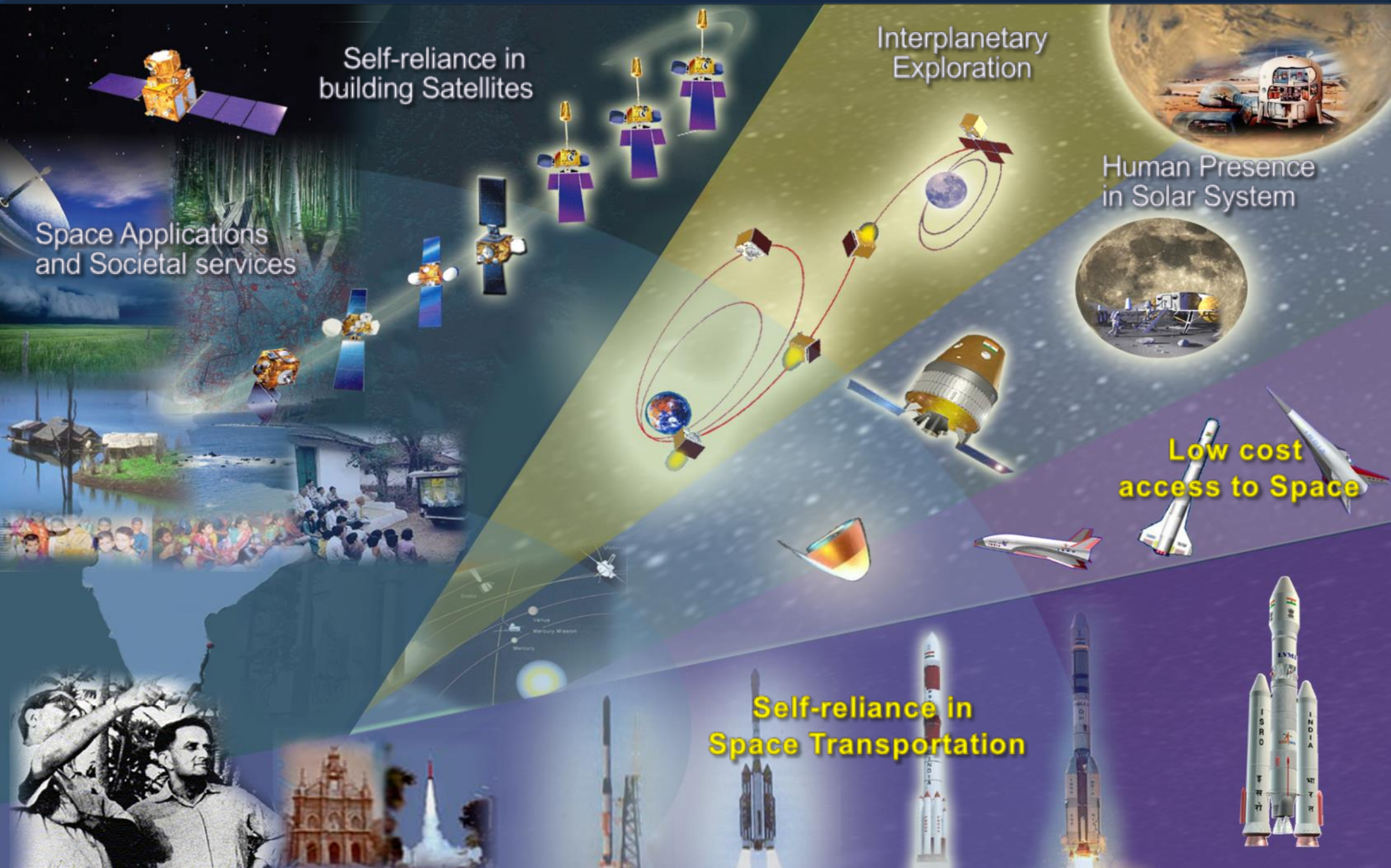


ISRO
Vision for Indian Space Program

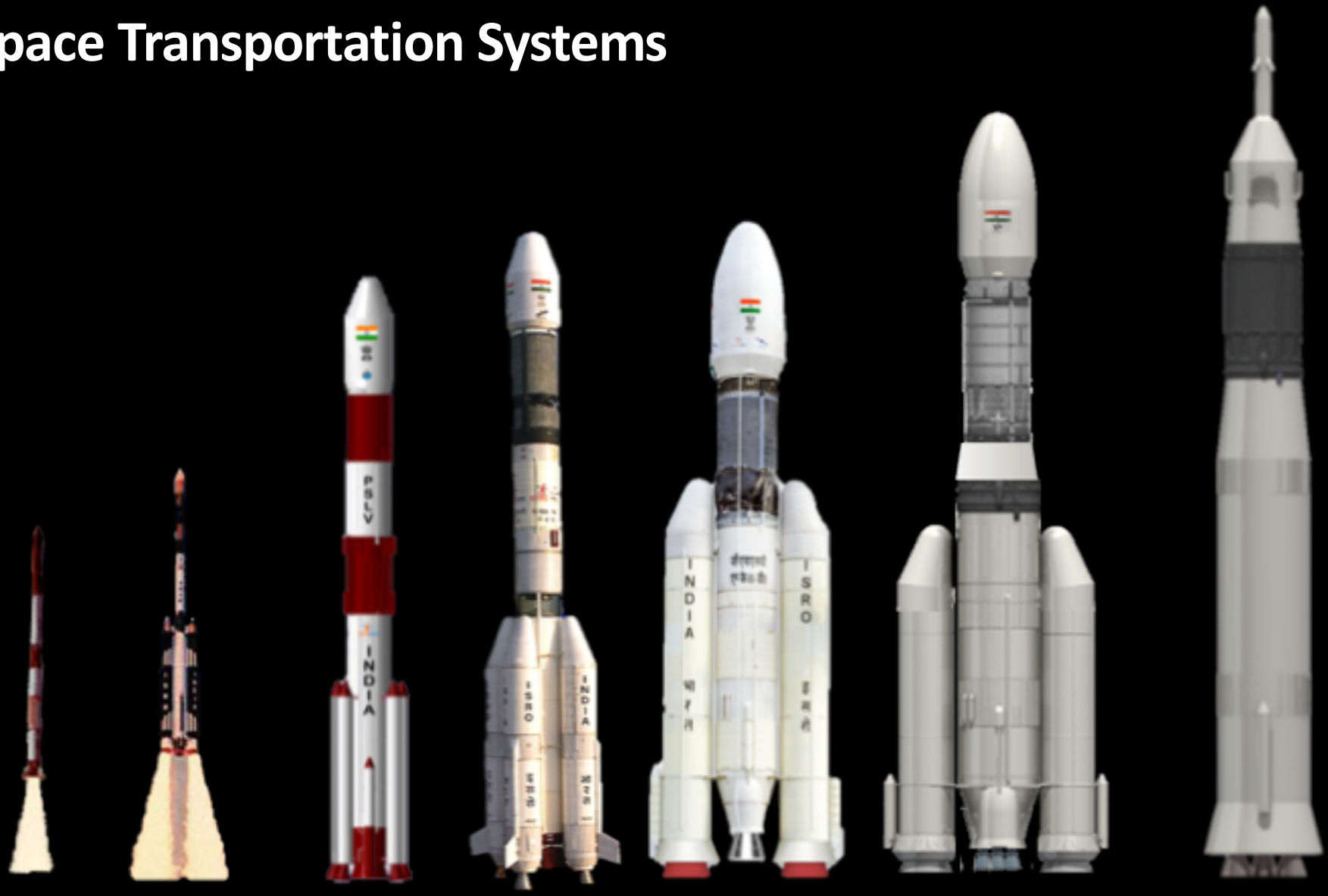
ESPI Panel discussion
Toulouse
26 June 2018

S. Somanath
Director
Vikram Sarabhai Space Centre
India

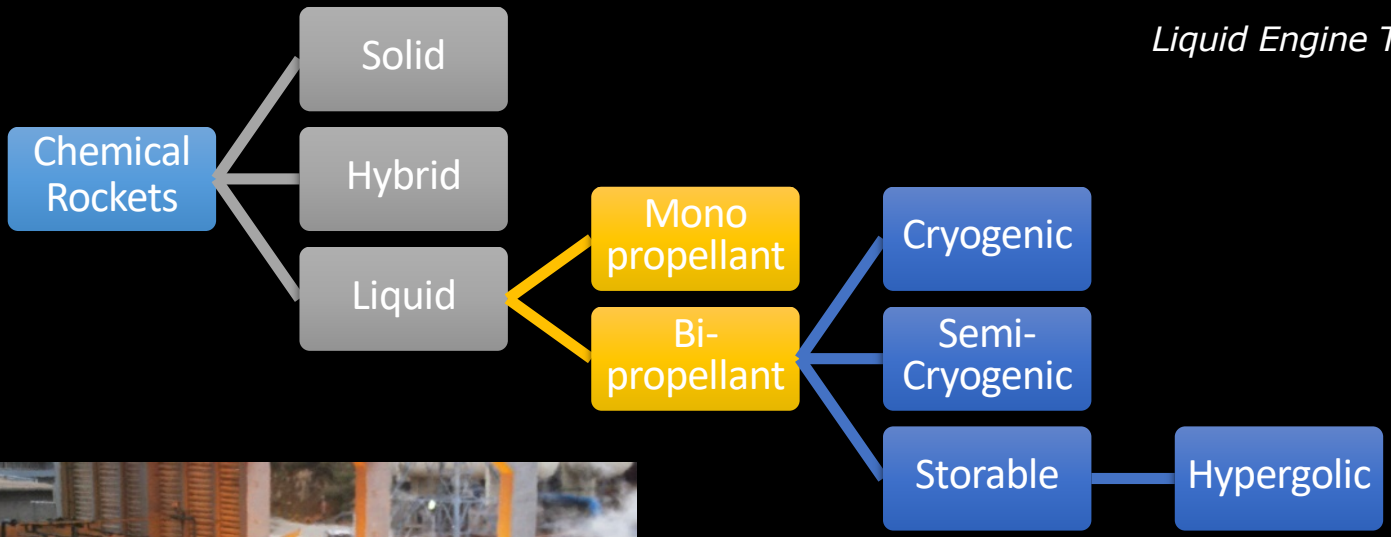
Indian Space Program



Space Transportation Systems



Launch Vehicle Propulsion



Liquid Engine Testing

Cryo Thrust Chamber Testing

Liquid Stage test

Solid motor static testing

Cryo Engine Testing

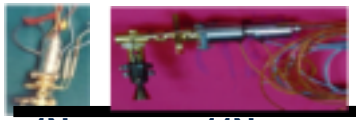
LIQUID ENGINES HERITAGE & DEVELOPMENTS

Engines from 75 mN to 2000 kN

ELECTRIC PROPULSION
XENON

75 mN

MONO-PROPELLANT



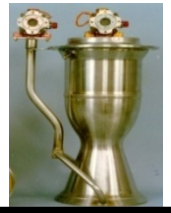
1N 11N

BI-PROPELLANT PRESSURE FED

22N

50N

440N



6.4 KN RCT

7.35 KN PS4

SATELLITE PROPULSION

CRYOGENIC - PUMP FED
LOX / LH2

75 KN CUS

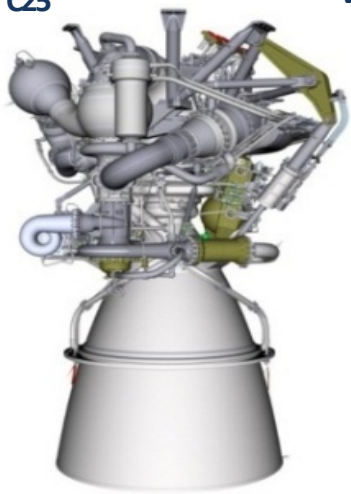
200 KN C25

BI-PROPELLANT PUMP FED /
N2O4 / UH 25

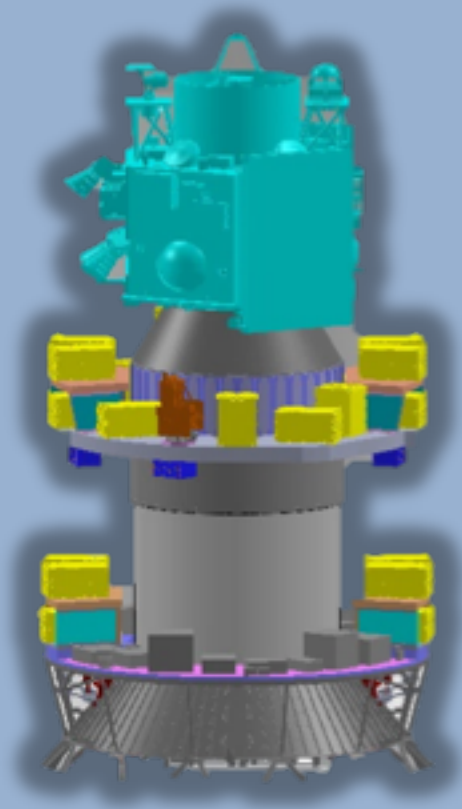
804 KN VIKAS

Under Development

SEMI CRYO ENGINE
2000 kN
LOX / ISROSENE



PSLV-C37: Mission with 104 Satellites



CARTOSAT-2D

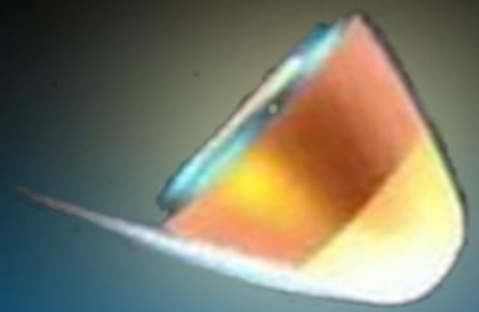
INS-1A & 1B

101 Microsatellites

1382.5 kg

PSLV C7 / Space Capsule Recovery

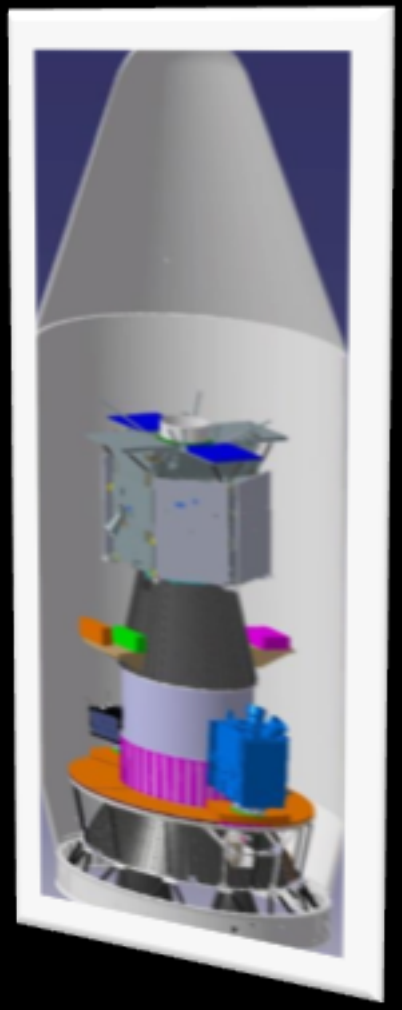
India's historic entry to the elite club of countries having reentry technology

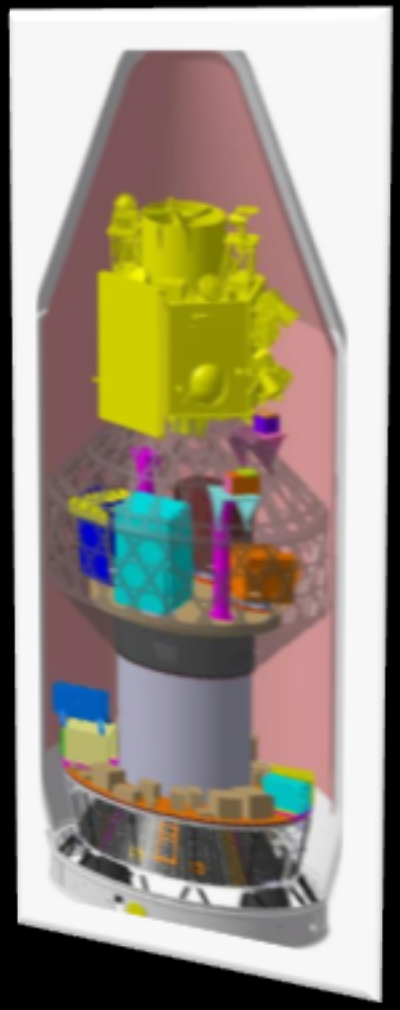


Launched on January 10, 2007

Recovery on January 22, 2007
at a pre-determined location in the
Bay of Bengal

PSLV: The Versatility Of Spacecraft Missions





Varieties of Spacecraft Mounting & Dispensing systems developed

Demonstrated the Re-start of 4th Stage of PSLV: Multiple orbit mission capability demonstrated.

GSLV: The New Operational Launcher

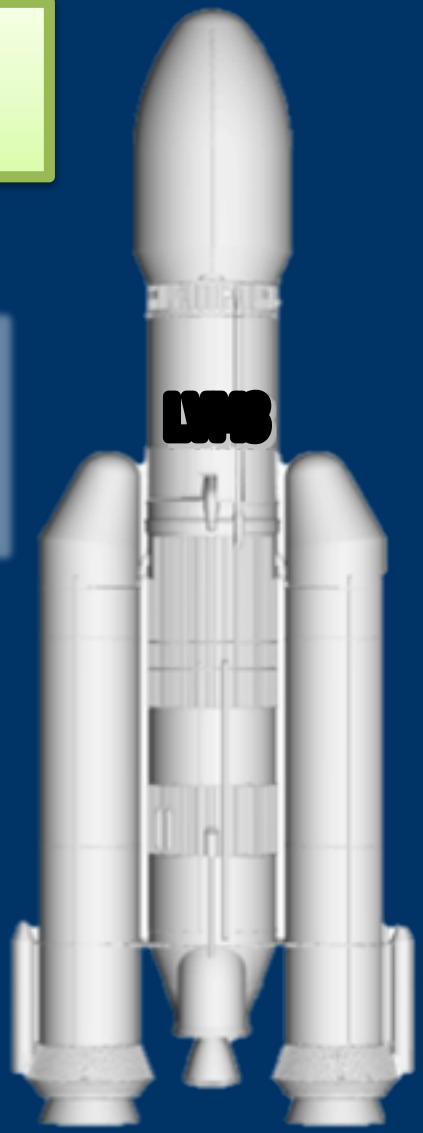
GSLV-F05 /INSAT-3DR
First Operational Mission

GSLV-F09
With GSAT-9
May 2017

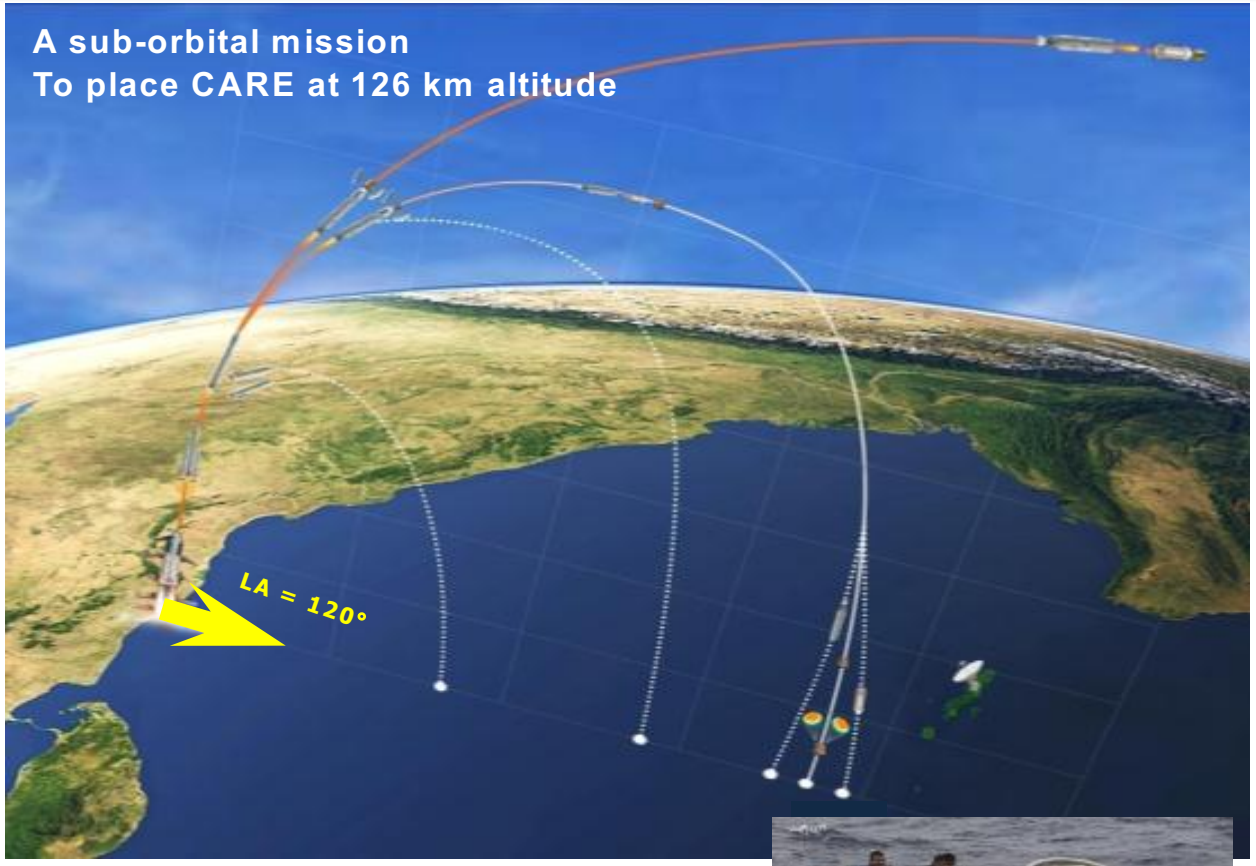
Progressive improvements in Payload capability up to 3000kg to GTO targeted.

GSLV Mk-III-D1: First Development Flight

C25 Cryogenic Stage proved in flight



LVM3-X/CARE Mission Outcome



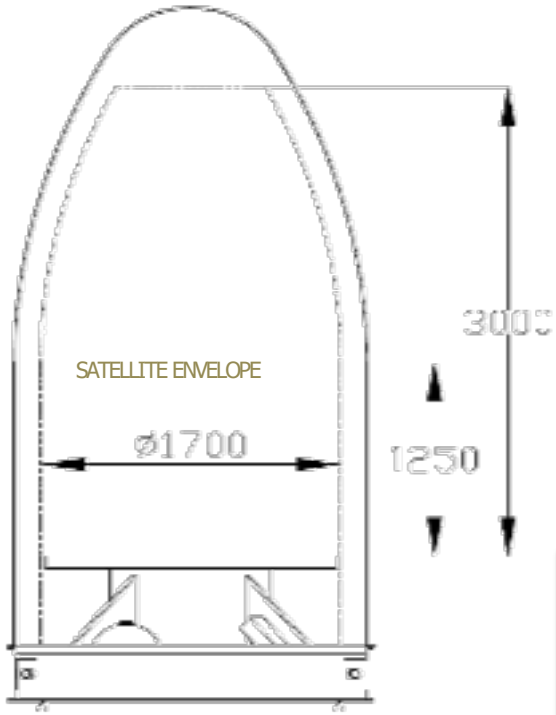
- LVM3-X / CARE mission
- Passive externally identical C25 stage.
- S200 & L110 flight demonstrated
- Demonstration of atmospheric flight regime.

CARE recovered near Andaman's after safe impact

SMALL SATELLITE LAUNCH VEHICLE

PAYLOAD CAPABILITY

Payload Volume ~5.8 m³



- Flexibility in accommodating multiple satellites
  - 500 kg - 1 no.
  - 200 kg class - 2nos.
  - 150 kg class – 3 nos.
  - 10 kg - Multi satellites on payload adapter

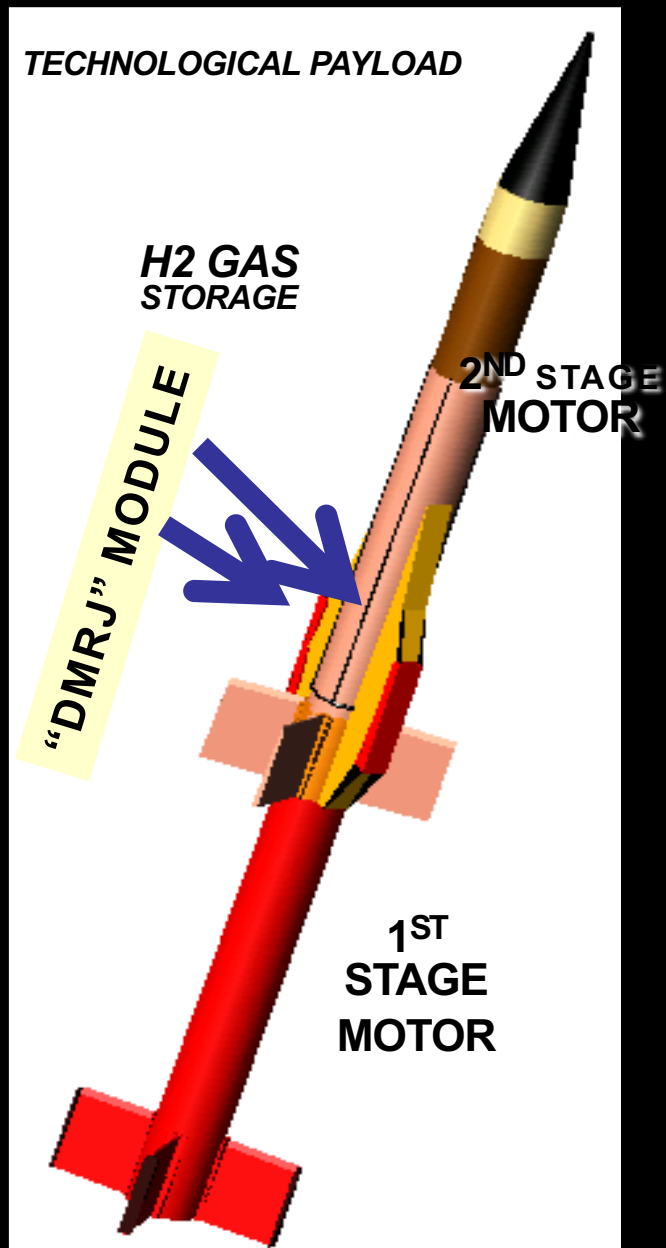
MISSION STUDIES

	From SDSC, SHAR	From suitable Launch site
Circular Orbit	LEO L.Az.135°, i=45°	SSPO L.Az.185°, i=97°
500 km	550 kg	300 kg
300 km	830 kg	560 kg

Injection accuracies :

- Semi-major axis : ± 20 km
- Eccentricity : < 0.003
- Inclination : ± 0.2 °
- Vehicle body rates at satellite separation : < 0.5 deg/s

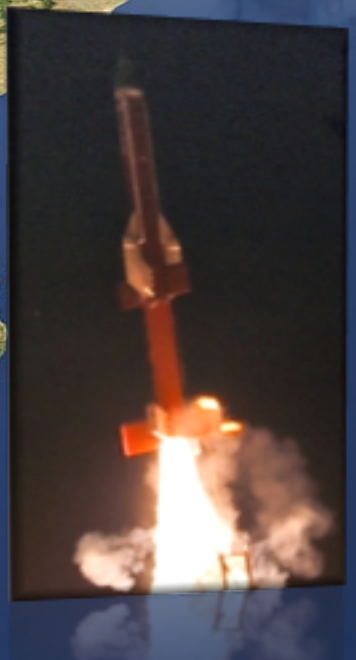
Air-breathing technology demonstration

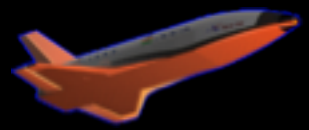


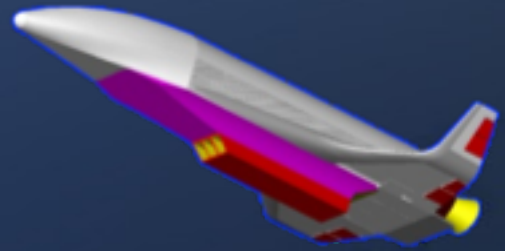
ADVANCED RLV WITH AIR BREATHING PROPULSION

ROCKET+DMRJ +ROCKET

Reusable Rocket & Air-breathing Propulsion



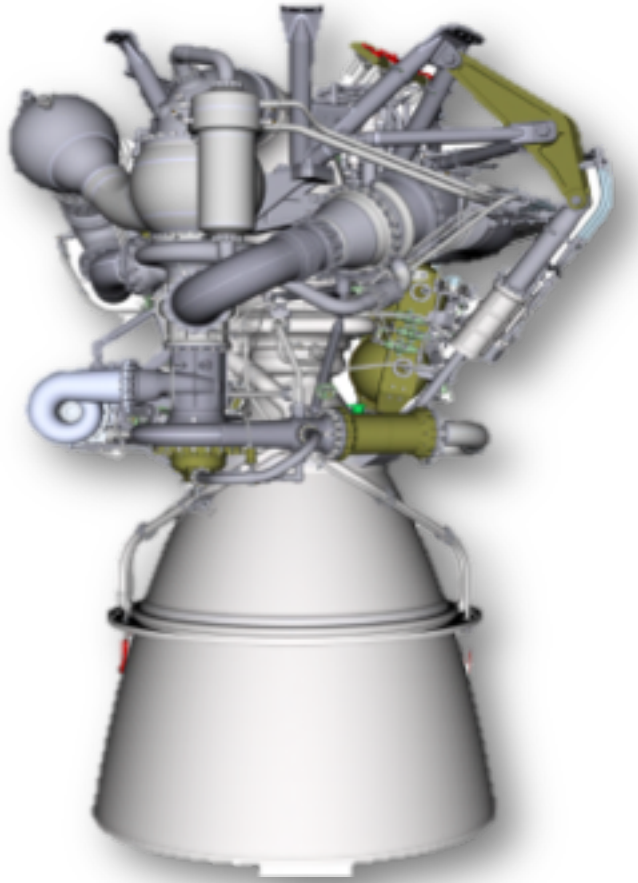




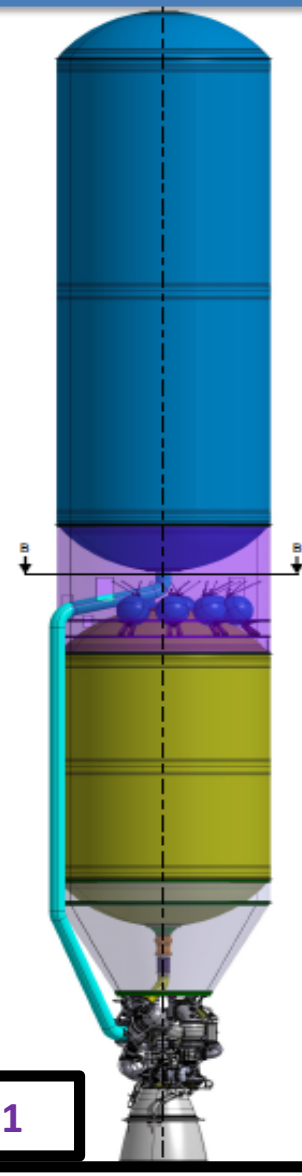
- RLV-TD Demonstration of winged Reusable Vehicle
- Air Breathing Technology Demonstration

Leading to Cost Effective Reusable Air-breathing Rocket

Semi-Cryo Evolution in STS



Semi-cryo Engine with 200 ton thrust



2021

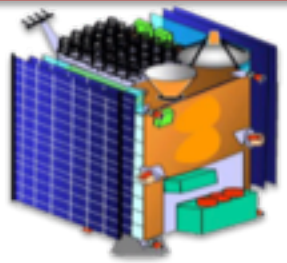
Semi-Cryo stage with 200 ton propellant loading

2024

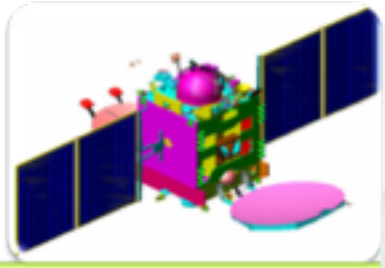
SC400 Stage Clustered Engines with 400 ton propellant loading

Electric Propulsion System

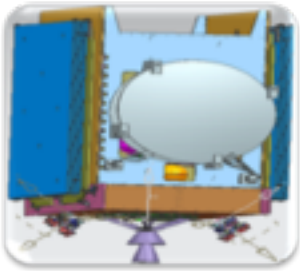
Indigenous Thrusters Designed, developed and qualified for our requirements



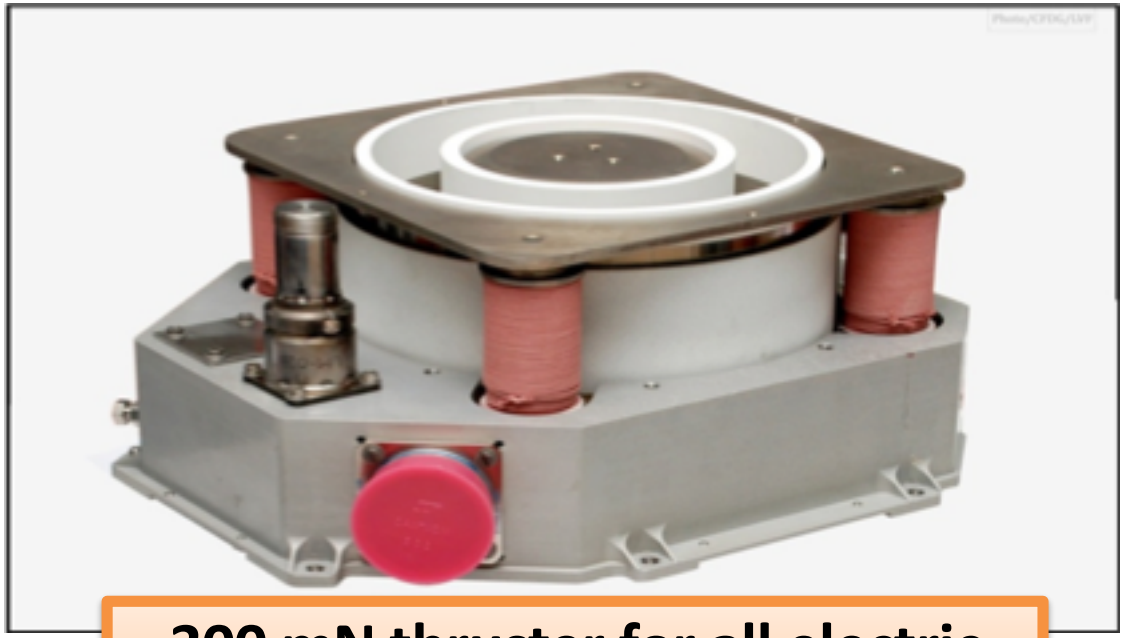
GSAT-4
Thrust : 18mN
Bus Power : 430 W



GSAT-9
Thrust : 18mN
Bus Power : 421W



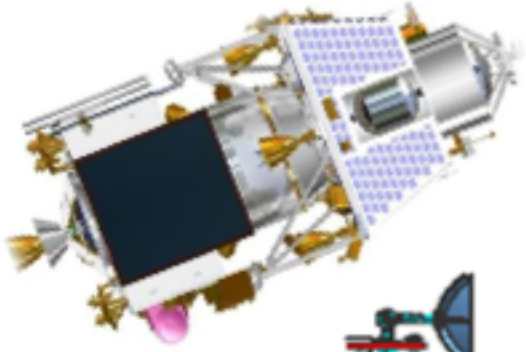
GSAT-19 & 20
Thrust : 75mN
Bus Power : 2.0 kW

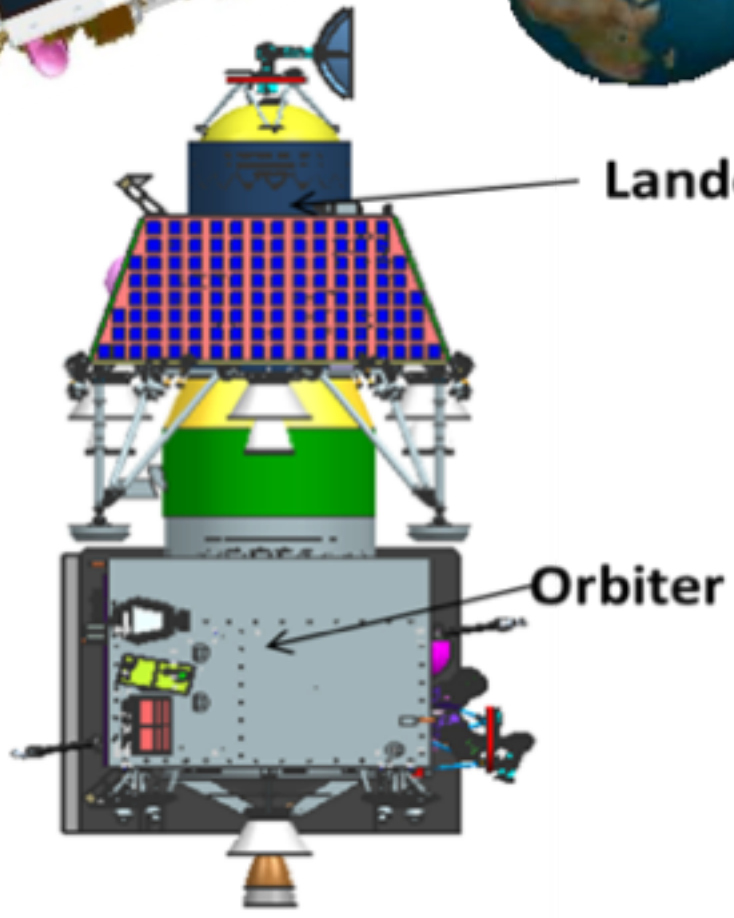


300 mN thruster for all electric propulsion spacecraft

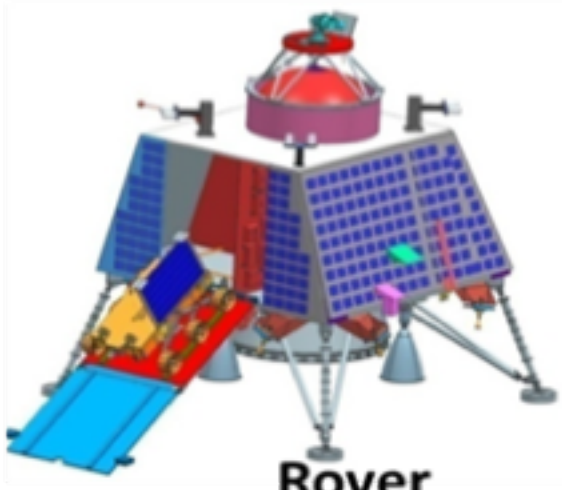
All Electric Propulsion Spacecraft of 3.5 ton is equivalent to a 6 ton conventional spacecraft in payload

Chandrayaan-II: Lander & Rover



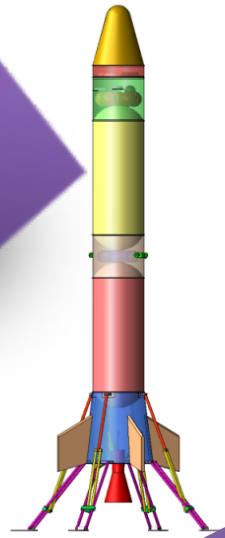


- Throttlable propulsion
- Landing demonstration
- Rover with wheels
- Increased science experiments

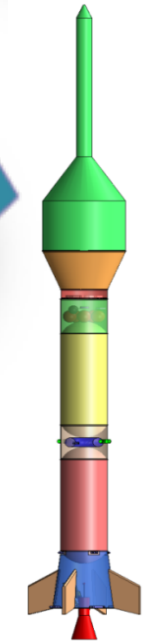


Throttleable and Restartable Engine for Test Vehicle

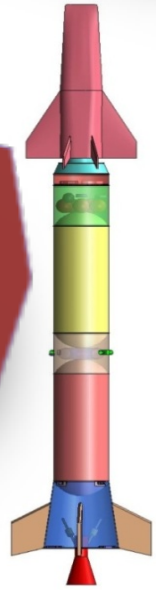
Demonstration of Spent Stage Recovery



Qualification of Crew Escape System



Carrier vehicle for Scramjet Research Vehicle



New Developments

Bi-propellant based Control power Plant

Throttlable and restartable Vikas Engine

Propellant Management System

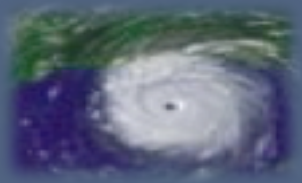
New hardware, tanks, structures, feedsystem design

Space Applications Verticals

- Food
- Water
- Energy
- Health
- Shelter
- Infrastructure
- Information

SOCIO ECONOMIC SECURITY

- Preparedness
- Early Warning
- Response
- Recovery



SUSTAINABLE DEVELOPMENT

SPACE APPLICATIONS DOMAINS

DISASTER RISK REDUCTION

GOVERNANCE

- Impact Assessment
- Resources Conservation
- Ecosystem Management
- Climate Change Impacts
- Geo-sphere Bio-sphere

- Planning
- Monitoring
- Evaluation
- Decision Support

National Services using INSAT Satellites

- Telecom Speech Circuits on Trunk Lines - DOT/BSNL
- TV Broadcasting, Direct-to-Home - Doordarshan
- Mobile Satellite Service, Search and Rescue, Satellite Navigation
- Private and News gathering services
- Radio Networking-All India Radio
- Cyclone Warning Dissemination Systems
- Training and Developmental Communication and GRAMSAT (Direct Receive Systems)
- Disaster Management Support, Emergency Communication, V-SATs
- Telemedicine, Tele-education
- 100 Meteorological Data Dissemination Centres
- Village Resource Centres

EARTH OBSERVATION SATELLITES

LAND & WATER

RESOURCESAT-2
LISS-3, LISS-4, AWiFS

RISAT-1
C-Band SAR

RISAT-2

HIGH RESOLUTION

CARTOSAT-2
0.8 m PAN

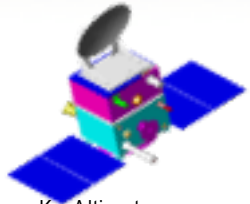
CARTOSAT-1
2.5m PAN stereo

CARTOSAT-Series

OCEAN

OCEANSAT-2
OCM, Scat, Rosa

SARAL



Ka-Altimeter

SCATSAT-1

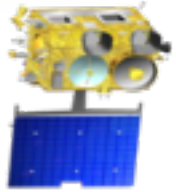
WEATHER; CLIMATE

INSAT-3A
VHRR, CCD

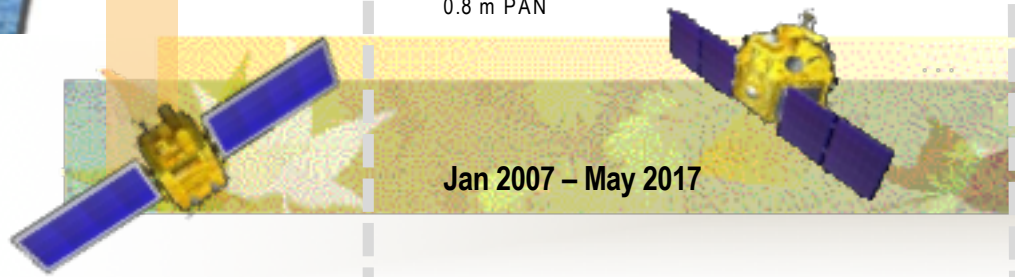
KALPANA
VHRR

INSAT-3D
Imager, Sounder

MEGHA-TROPIQUES
MADRAS, SCARAB, SAPHIR, ROSA

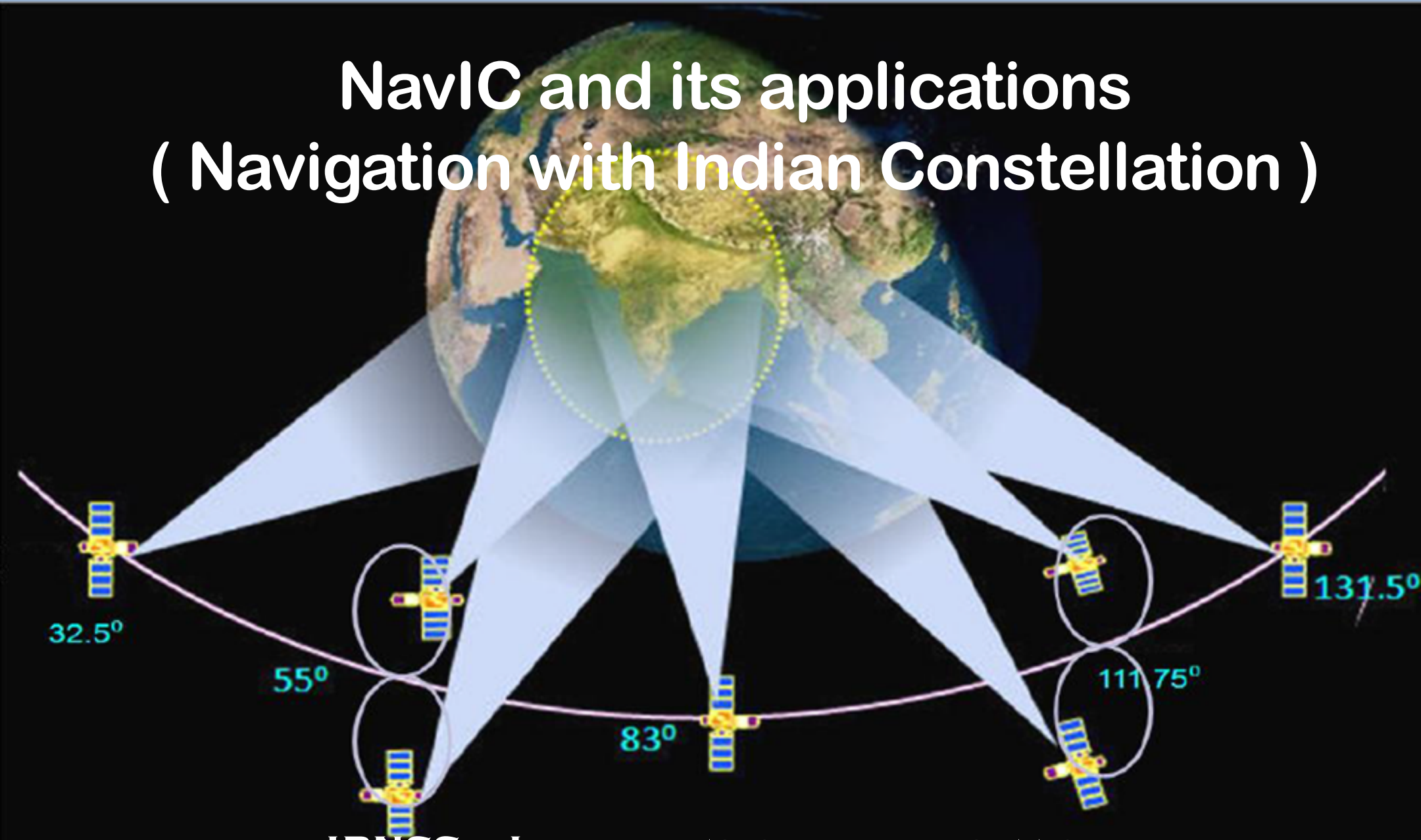


INSAT Series



Jan 2007 – May 2017

NavIC and its applications
(Navigation with Indian Constellation)



IRNSS – Indian regional navigation satellite system

Recently Realised Spacecrafts

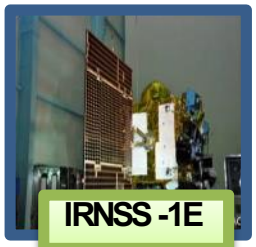
10 +4 Satellites Realized

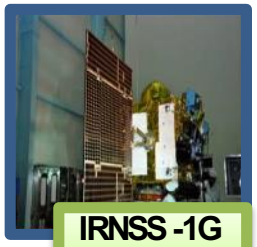
Academia

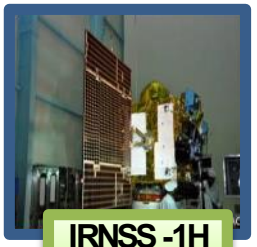
Satellite based Work Centres

Indian Industries

NAVIC Satellites

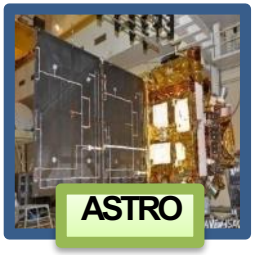






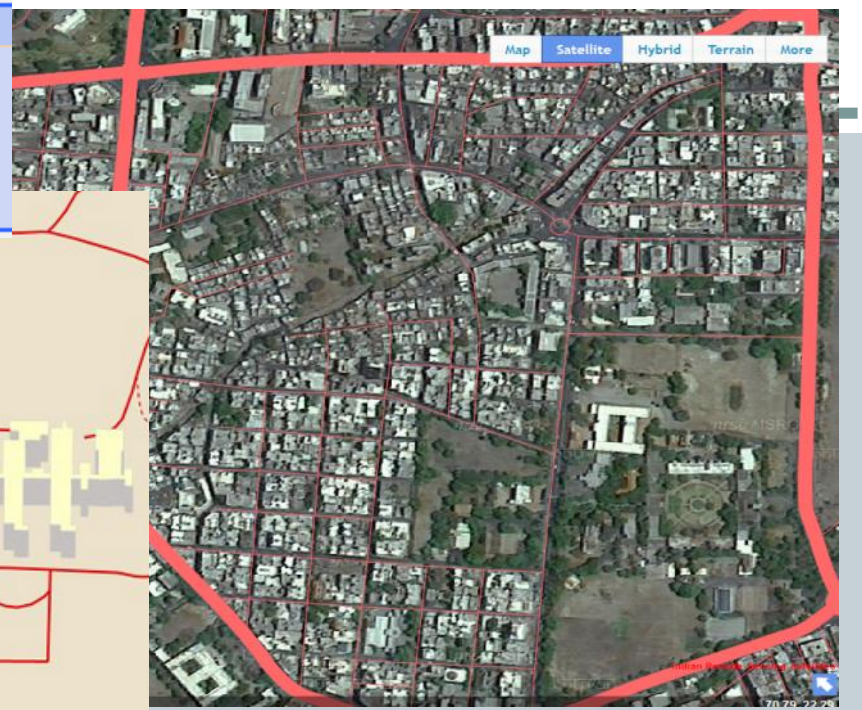
GEOSAT Satellites

Remote sensing & Microwave Imaging Satellites



University Satellites

Bhuvan Applications
for G-Governance



NATIONAL REMOTE SENSING CENTRE
INDIAN SPACE RESEARCH ORGANIZATION
DEPARTMENT OF SPACE, HYDERABAD

BHUVAN – Indian Geo-Platform of ISRO

Visualization (100TB) and Free Download

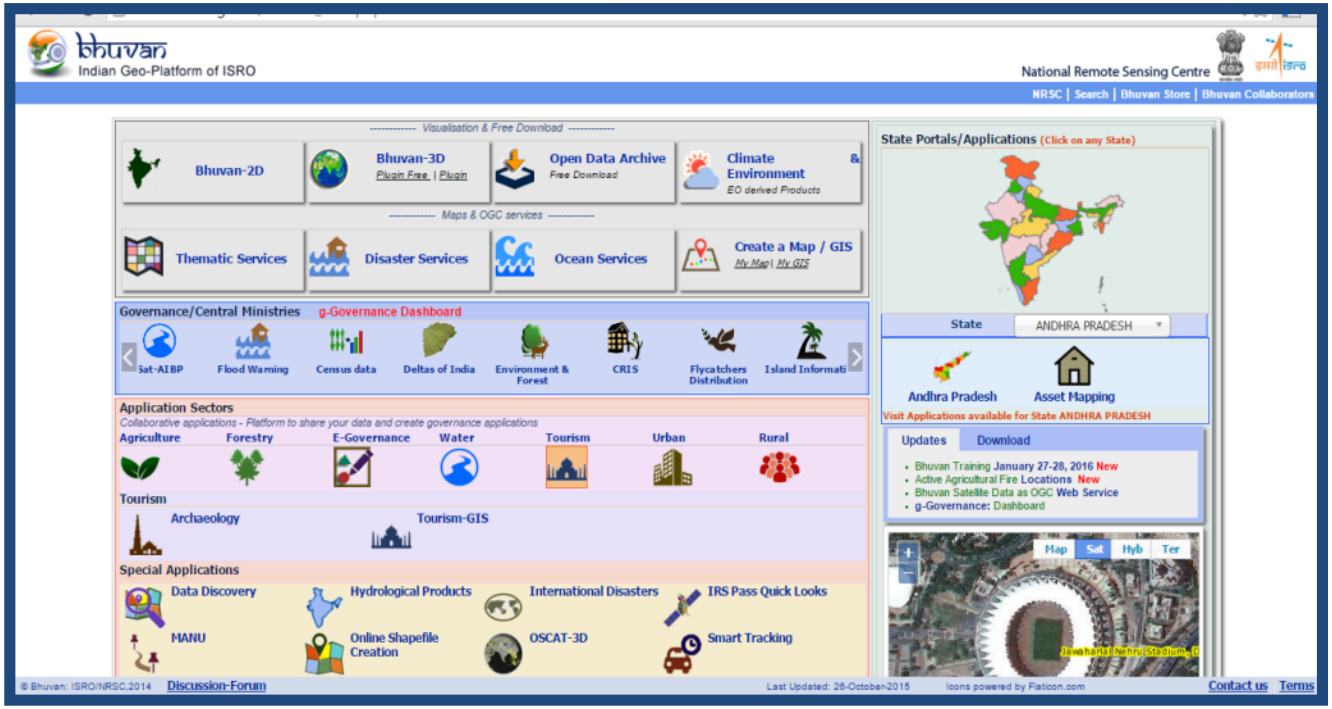
Maps & OGC Services (~7000+)

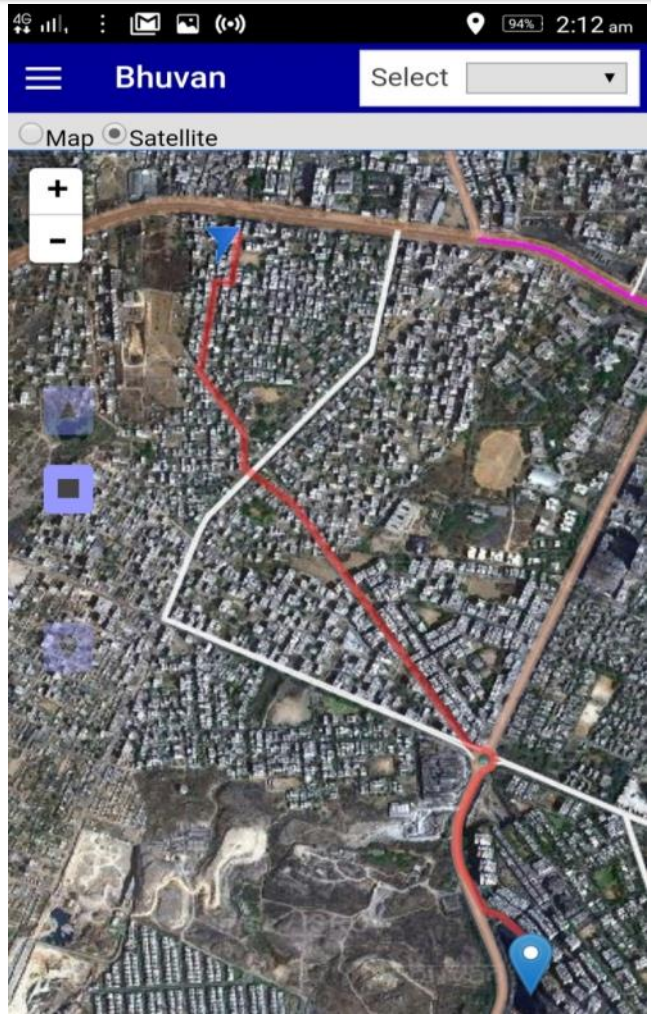
Applications (200+)

State Portals (30)

Crowd Sourcing (14 M)

Bhuvan Locate Android Application



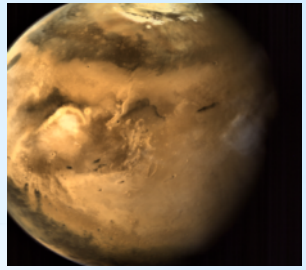


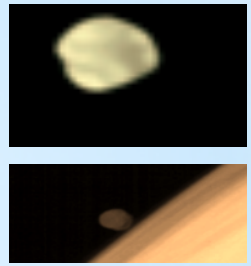
- More than 1 lakh Registered users
- 36K unique visitors/day
- 6.38 lakhs free download

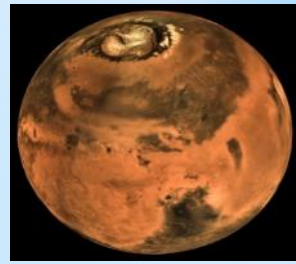
- ✓ *Location Tracking*
- ✓ *Real time Navigation*
- ✓ *Find Route*

Mars Orbiter Mission - Achievements

Completed the design mission life of 6 months on Mar 24, 2015 & One Martian year (687days) in its orbit on Aug 10, 2016. Still going on very well.







Challenges and achievements in Martian orbit

- The spacecraft came out of 'blackout' and 'whiteout' geometry successfully with the help of MOM's built-in autonomy.
- Images of the full Martian disc with a single snap shot
- Image the far side of Deimos for the first time

- Produced 590+ images
- 16 Publications in peer reviewed journals
- Made AO to utilise MOM data (Approved 32 proposals)

Released MOM data to public on 24 Sep 2016 URL: https://mrbrowse.issdc.gov.in/MOMLTA

Statistics as on 30 Sep 2016 09:00 hrs IST

Total Number of Users Registered :608
Total Number of Downloads :1550

Albedo studies using the 1.65 micron of the reference channel of **MSM**

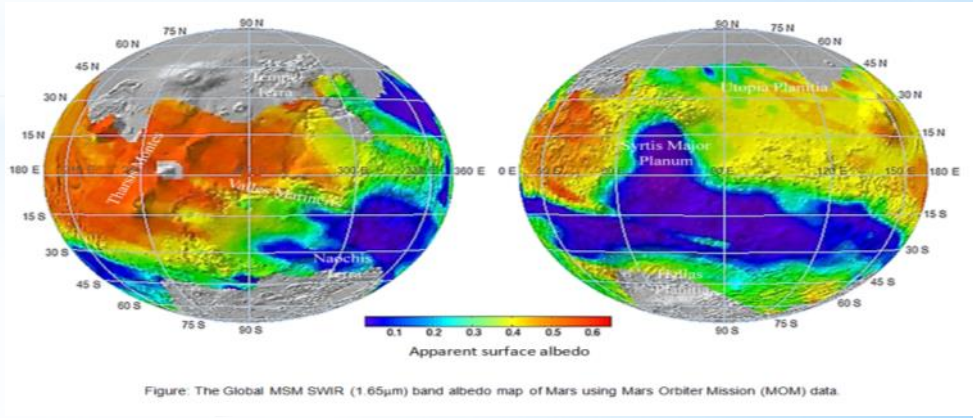
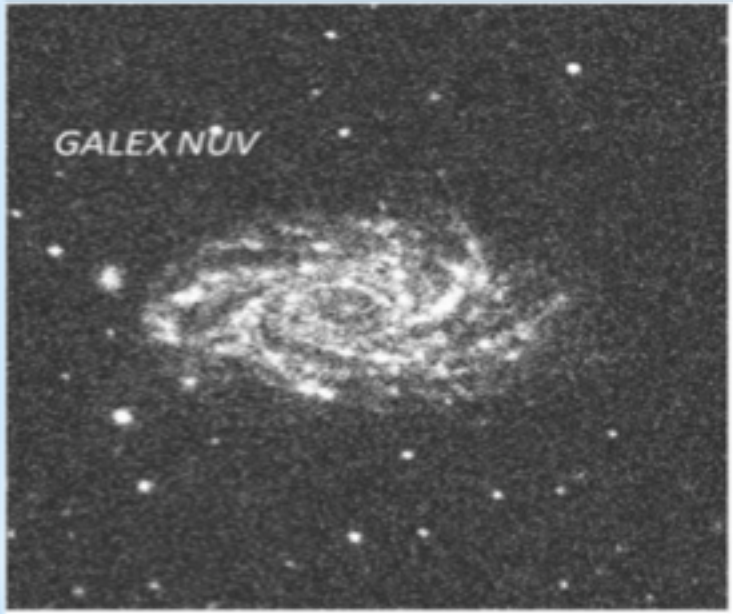


Figure: The Global MSM SWIR (1.65μm) band albedo map of Mars using Mars Orbiter Mission (MOM) data.

Results

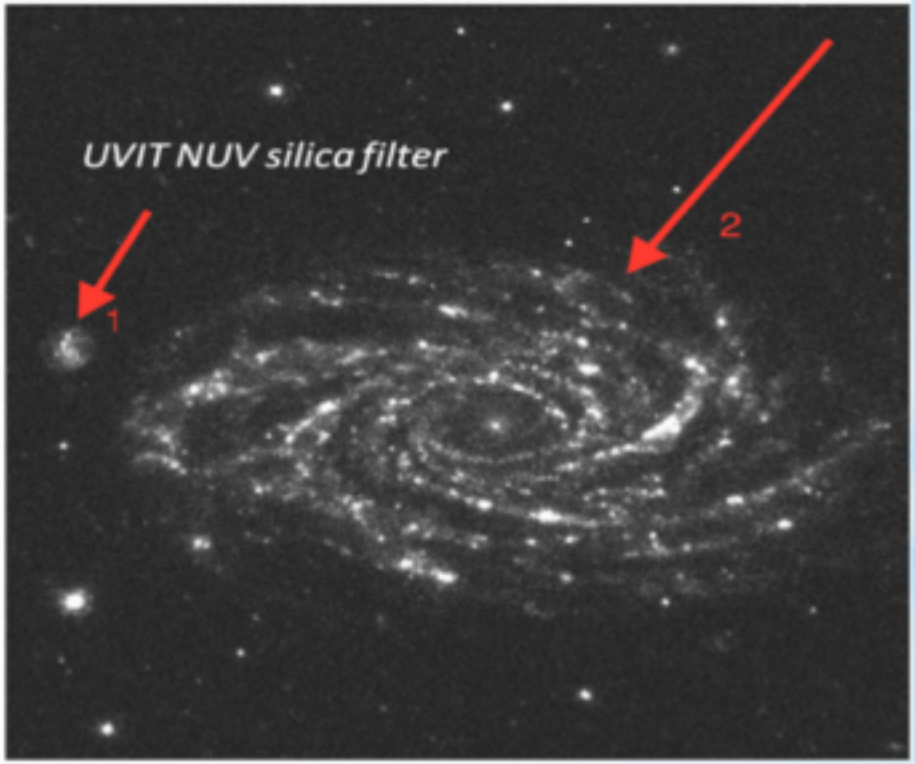
The dust patterns around high altitude regions were studied and mean height of dust layer was estimated to be ~1.5 km.

ASTROSAT: Comparison of NGC 2336 by UVIT with GALEX image



GALEX image

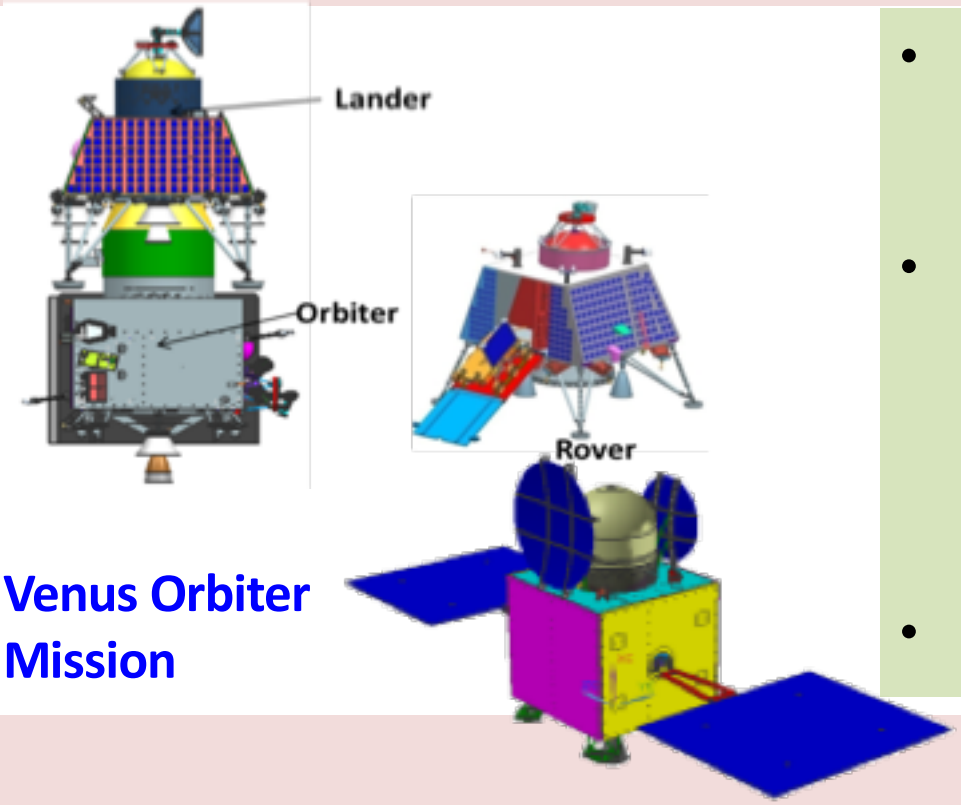
ASTROSAT image



1 The nearby Galaxy is resolved.
2 The spiral arms are clearly visible and well separated.

GALEX mission of NASA was a successful UV mission with large field of view and image resolution of 6 arcsec. UVIT has near and far UV resolution in the order of 2 arcsec and Field of View (FOV) of about half a degree.

Furthering Space Exploration



Venus Orbiter Mission

- **Chandrayaan-2**
  - Realisation , Launch, LOI, Orbiting, Landing, Roving, Observations, Results
- **MOM-2**
  - Continue observations and science results; Capacity building
  - Explore reducing Periapsis for near Mars observations by Aero braking
- **Mission to Venus**

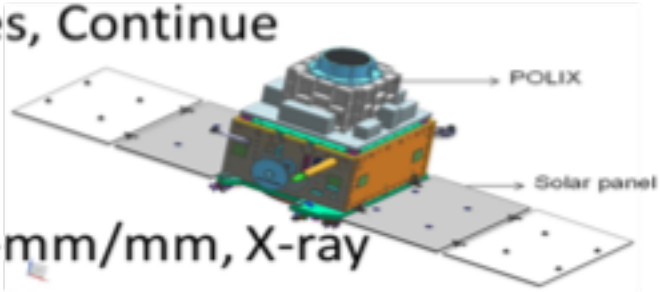
XPoSAT: X-Ray Polarimeter

XPoSAT First mission devoted to X-ray polarisation studies, Continue observations and science results.

Study of Exoplanets Observations and results.

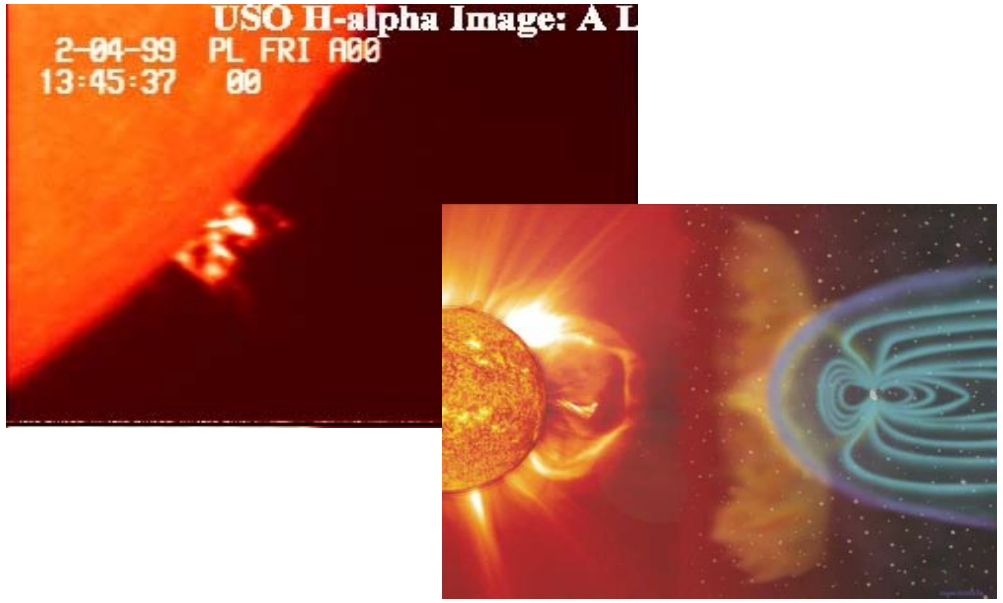
AstroSat follow-on Next Astronomy Mission IR, UV, Sub-mm/mm, X-ray

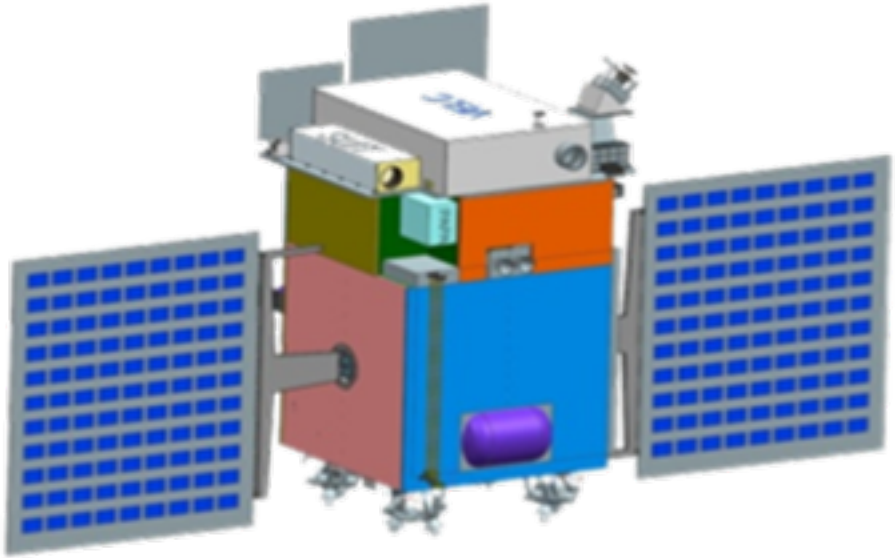
FM Payload development, realization and launch.



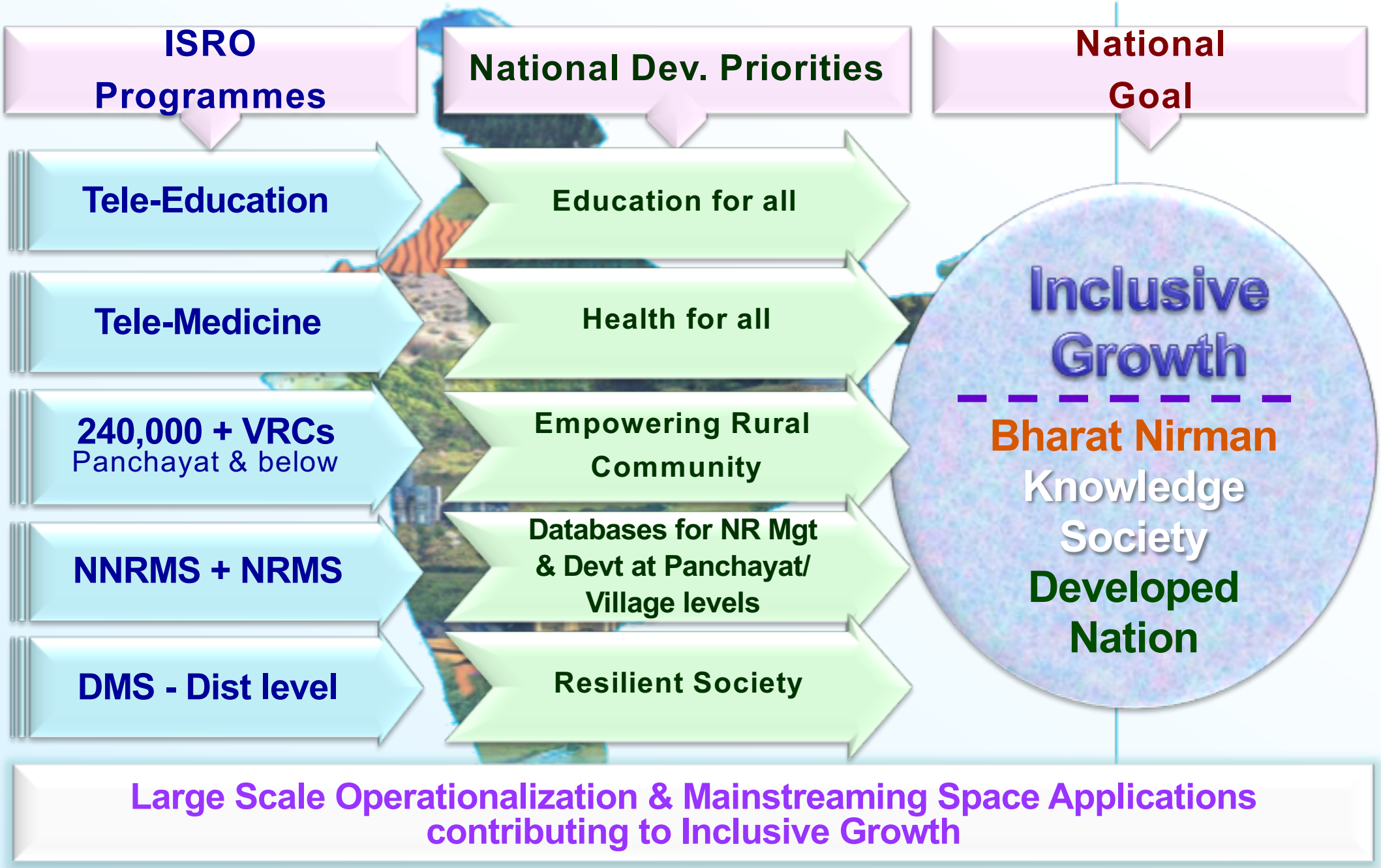
Aditya L1: Study of Solar physics

- First Indian mission to study the Sun from L1 orbit – Continue observations and science results.
- Halo orbit around L1.
- **Launch: 2020 by PSLV -XL** .
- Instruments: Coronagraph, UV imager, soft and hard X-ray spectrometers, particle experiments and a magnetometer.
- **L5 Space weather mission:** Realisation and launch of the mission.
- **Follow-on Aditya mission: In** Study phase





Space Applications in India: Vision



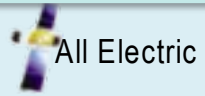
SPACECRAFTS FOR COMMUNICATION & NAVIGATION: ROAD MAP

2017 | 2020 | 2024 | 2030

Communication

15 Missions → + 9 - 2 → 22 → + 20 - 3 → 39


HTS-90Gb


All Electric


Q/V High Frq. band


Agile-Flexible Sat


MobiSat


Optical Com


Global Coverage


Electric Prop.


Space-to Space Com


Arctic Coverage


High Power DTH


AIS,UHF TrackSat


LEO-MEO ComSat

Next Gen High Throughput, Mobility, IOT, Digital Stream Maritime, Aviation, Global coverage satellites

Navigation

7 Missions → + 4 → 11 → LEO/ MEO/ GEO


Enhanced NavIC Sat Constellation


Triple band (L1,L5&S)

Global NavIC Sat Constellation

New Generation GAGAN

INDIA: Our Assets & Aspirations

Human Resources

1.25 Billion people
64% - 15-64 age group
31% - 0-14 age group..

Aspirations Education, Health, Prosperity, Security..

Economy (6.6% growth)

PPP - $ 3.2 trillion - 5th largest
Agriculture - 17%
Industry - 29%
Services - 54%

Aspirations Accelerated, Balanced & Equitable Growth

Natural Resources

Area - 328 Mha (142 Mha NSA)
Rainfall - >110 cm ave.
Coastline - 7,500 km
Diverse Ecosystems

Aspirations Conservation, Management, Development…

Physical Infrastructure

Phone/ Mobile - 340 M/ 360 M
Railways line - 63,000 km
Roadways - 300,000 km
Waterways 14,500 km
Dams, Reservoirs, ..

Aspirations Building, Modernizing, Maintaining, …

Space enabled Solutions

Tele-education, Tele-medicine
Natural Resources Mgt.,
Disaster Mgt. Support, Village Resource Centres, Knowledge, Innovation, ..

INDIAN SPACE TRANSPORTATION SYSTEM ROADMAP

2018 | 2020 | 2024 | 2030

PSLV

6 - 8 PSLV per Year

R&D towards cost effectiveness

Production by Industry

8-12 PSLV per Year

Launch Pad

12- 18 PSLV per Year

Capacity building for Increased Launch Frequency

GSLV & its Variants

2 – 3 Launches per year

2.2t

Payload Improvements

3t

4t (10t)

5t

Payload Improvements

4 – 6 Launches per year

6.5t

7 – 10 Launches per year

Modular Launch Vehicle Family for 5t to 16t payload capability

Advanced Launch Vehicle

Modular Launch Vehicle Family

Third Launch Pad

SC Stage

SC engine

CSC Stage

5t (11t)

10t (23t)

11t (25t)

16t (41t)

Reusable Launch Vehicle

Demonstrator tests for critical technologies.

Development, Realisation, Qualification and Test Flight

Transportation of Humans to Space

Demonstration of key technologies

Crew Escape System

Orbital Vehicle

Orbital Vehicle Demo

Establishment of Human Transportation Technologies

Robotic Missions

Reliability Demonstration

s_somanath @ vssc.gov.in
sssnath @ gmail.com